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(54) **A stent for angioplasty and associated production process**

Ein Stent für Angioplastik und damit verbundenes Produktionsverfahren

Stent pour angioplastie et son procédé de production

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Description

[0001] The present invention concerns a stent for angioplasty and an associated method of production thereof.

[0002] The term "stent for angioplasty" is intended to indicate generally devices intended for endoluminal application (for example, within a blood vessel) in association with the technique of percutaneous transluminal coronary angioplasty, or PTCA, usually effected by catheterisation of a stenotic site.

[0003] Expanding the stent at the site causes the lumen to expand giving rise to the consequent elimination of the stenosis, and the local support of the lumen by the stent, which is left in place expanded, avoids restenosis of the treated site due to the subsequent relaxation of the blood vessel wall. The use of a substantially similar structure for deploying vascular grafts and fixing them in place has already been proposed in the art: naturally, this possible extension of the field of application should be seen as included within the ambit of the present invention.

[0004] For a general review of vascular stents, reference may usefully be made to the work "Textbook of Interventional Cardiology" edited by Eric J. Topol, W. B. Saunders Company, 1994 and, in particular, to section IV of volume II, entitled "Coronary Stenting".

[0005] Many patent documents have addressed this problem, for example, US-A-4 776 337, US-A-4 800 882, US-A-4 907 336, US-A-4 886 062, US-A-4 830 003, US-A-4 856 516, US-A-4 768 507 and US-A-4 503 569.

[0006] The implantation of these devices, which is a factor in the treatment of various cardiac diseases, may require, or at least gain particular benefit from the possibility of being able to administer at the stent-implantation site agents or active principles (the two terms being used below in an equivalent sense) having various end purposes: they may, for example, be antithrombogenic agents or, more generally, agents for directly resisting restenosis of the treated site due to the formation of deposits, tissue proliferation, etc. In relation to this, reference may usefully be made to the following works:

> "Local Drug Delivery: The Development of a Drug Delivery Stent" by Richard Stack, The Journal of Invasive Cardiology, Vol. 8, n. 8, October 1996, pp 396-397;
>
> "Local Intraluminal Infusion of Biodegradable Polymeric Nanoparticles" by Louis A. Guzman et al.. Circulation, 1996; 94; pp 1441-1448;
>
> "Local Angiopeptin Delivery Using Coated Stents Reduces Neointimal Proliferation in Overstretched Porcine Coronary Arteries" by Ivan De Schreerder et al., the Journal of Invasive Cardiology, Vol. 8, n. 8, October 1996, pp 215-222.

[0007] Many applicational problems arise from this mode of operation, mostly related to the specific solutions adopted. For example, the problem exists of avoiding the agent or agents intended for administration in the zone of the stent being delivered or transported to different areas where they may have negative or damaging effects. Other problems may arise, for example, in ensuring the permanence and the gradual release over time of active substances capable of being, as it were, washed away by the blood passing through the stent.

[0008] These problems cannot themselves be solved or avoided by recourse to other solutions such as radioactive stents or so-called biodegradable stents, as illustrated, for example, in the work "Biodegradable Stents: The Future of Interventional Cardiology?" by M. Labinaz et al; Journal of International Cardiology, Vol. 8, n. 4, 1995, pp 395-405. Radioactive stents publicly proposed so far give rise to other problems related essentially to the fact that, in most cases, their use assumes the typical features of radiotherapy and/or nuclear medicine. The main disadvantage of biodegradable stents is that, at least in the long term when the stent has completely or substantially degraded, there is a reduction in the mechanical support of the blood vessel wall against the risk of collapse.

[0009] As a further solution for administering various kinds of active principle at the stent-implantation site a solution has recently been proposed in which at least a portion of the surface of the body of the stent (or implantation device in general) is coated with a receptor capable of binding with a ligand formed by combining an active principle with a substance capable of binding to the receptor.

[0010] In order for this new solution to be fully beneficial, that is, so that it can also be used with more conventional techniques for effective topical administration of the active principles, it appears important to obtain a good adhesion and/or retention on the stent of the substance or substances with which these active principles are associated and/or are intended to be associated.

[0011] In relation to this it is therefore necessary to take account of various concomitant factors which often oppose one another.

[0012] In a significant number of applications it is important that the active principles are present mainly, although not exclusively, on the outer surface of the stent. Conversely, it is usually desirable that the inner surface of the stent itself is as inert as possible, that is, both from the chemical point of view and from the point of view of the possible mechanical anchorage of possible deposits.

[0013] This is the reason why currently available vascular stents are subjected to a polishing process, intended to make the surface of the stent (both inside and outside) very smooth. In relation to this, it is also possible to coat the stent with a layer of biocompatible material, such as a biocompatible carbon material (deposited, for example, using sputtering techniques), so as to confer a high degree of haemocompatibility on the whole stent.

Adopting this technique for the deposition of such a layer, given the very small dimensions of a stent for angioplasty, means that it is practically impossible to limit the deposition to just the inside surface of the stent. Consequently therefore, the entire surface of the stent is coated with a layer which, by its nature, makes the deposition of substances on the stent itself, in fact, impossible.

[0014] A further factor should not be forgotten: a stent for angioplasty is by its nature a heavily apertured structure, usually a mesh-like structure in which, especially in the radially-extended position, the effective surface intended to come into contact with the blood vessel wall is a small fraction of the theoretical tubular surface area defined by the outside of the stent itself. In other words: even by putting the other problems described above to one side, there is very little available surface on the stent for carrying the active principles intended for local delivery.

[0015] More specifically, the present invention relates to a stent and method having the features set forth in the preambles of claims 1 and 12, respectively. These are known, e.g. from EP-A-0 747 069.

[0016] The object of the present invention is that of resolving the disadvantages described above.

[0017] In particular, the solution according to the invention, having the characteristics set forth in the characterizing portions of claim 1 and claim 12, enables the selective application, specifically to the outer surface only of the stent, of a completely effective quantity of active principle (either directly or in the form of a receptor capable of binding with a ligand carrying the active principle) without by this losing the possibility of having a very smooth surface, at least inside the stent, even if clad with coatings such as haemocompatible carbon coatings.

[0018] The invention, which concerns a stent as well as the associated process for the manufacture thereof, will now be described with reference to the accompanying drawings, comprising Figures 1 to 6, wherein Figure 5 shows a possible embodiment of the invention.

[0019] In all of the accompanying Figures, the reference numeral 1 indicates a wall portion of a stent for angioplasty. By way of example, Figures 1 to 6 can be considered as partial views on an enlarged scale of a segment of a stent in transverse section. Such a section is usually circular in shape regardless of whether the stent is radially-contracted or radially-expanded.

[0020] The specific details of construction of the stent and, in particular/ its geometry, are factors which are in themselves clear in the context of the invention and which apply regardless of the particular structure of the stent. This is also substantially true as regards the basic manufacturing technique (for example, starting from a wire or microtube which is then subjected to an operation for cutting the apertures, for example, using lasers) and/or the material (usually metal) of which the stent is made. All of these factors are dealt with in a fairly large volume of literature and do not require detailed description here.

[0021] In essence, all the arrangements shown provide for the formation of surface sculpturing on the stent 1, at least - and preferably - over a part of, or the whole of the outer surface, indicated 2, and having substantially the aim of:

- increasing the theoretical surface area of the stent in order to encourage the application of coatings, such as those intended to carry or bind active principles,
- creating in any case undercuts and roughness so as to form anchorage sites for the substances, without requiring specific surface-adhesion sites, and, as a complementary advantage,
- improving the attachment of the stent to the blood vessel wall that is already in the acute phase, specifically by preventing relative movements which can give rise to microlesions.

[0022] For clarity, the term "sculpturing" is used to distinguish clearly the surface conformation attributed to the stent according to the invention from the degree of surface (residual) roughness that the surfaces of the stent have in any case, even when they have been previously subjected, according to convention, to a polishing or finishing process.

[0023] By way of example, one such treatment confers such a degree of residual roughness on the stent surfaces that the peak-to-trough distances recognisable in a theoretical section of the surface in question at right angles to the surface itself are not, in any case, greater than approximately 2-3 microns.

[0024] The degree of surface irregularity, or sculpturing, characteristic of the invention is, instead, such that the peak-to-trough distances found in similar conditions are, typically approximately 10-20 microns, that is, with the possibility of achieving values of an order of magnitude even greater than those of the normal surface finishing of a stent.

[0025] Figures 1 to 6 illustrate different techniques that can be used to confer the desired degree of sculpturing on the surface 2.

[0026] In particular, Figure 1 concerns the application of microspheres 3 formed from the same material (usually metal) as the stent or from different materials with the subsequent anchorage of the microspheres (the average diameter of which is approximately 10-20 microns) using the method known as "hot partial melting". This is a method known in the art and is used, for example, to confer a surface appearance approximately similar to the surface appearance characteristic of a work-piece obtained by sintering the surfaces of mechanical work-pieces intended for various purposes. From this one understands that such an arrangement can be practised also in connection with a stent realized, as a whole, or at least in those part(s) corresponding to the surface sculpturing, by sintering.

[0027] Figure 2 concerns a variant of the arrangement illustrated in Figure 1 in which, while retaining the same typical surface irregularity, irregular-shape granules 4 are used in place of the microspheres 3. The same remarks made in the foregoing in respect of possibly manufacturing the stent, at least partly, by sintering apply also in this case.

[0028] Figure 3 illustrates a further arrangement based on the deposition of a receptor material using, for example, sputtering or plasma spray techniques to form an irregular-shape accretion, for example, having a pseudocolumnar structure.

[0029] From this point of view, the solution according to Figure 1 (the application of microspheres) seems to be preferred when it is desired to create undercuts and roughness on the surface 2, having a mechanical anchorage function and precisely defined geometric characteristics which are identified by the (precisely determinable) grain size of the microspheres 3.

[0030] Conversely, the arrangement shown in Figure 3 appears preferable where the objective is to maximise the effect of increasing the theoretical surface area that is effectively exposed. This latter solution is therefore preferred when, for example, it is desired to apply a coating to the surface of the stent 1, which coating transports and/or is intended to transport active principles and is essentially in the form of a monomolecular layer.

[0031] The arrangement according to Figure 2 constitutes, to a certain extent, a kind of intermediate between the arrangements of Figures 1 and 3.

[0032] The arrangements to which Figures 1 to 3 refer, which comprise possible equivalent arrangements, are characterised essentially by the fact that the surface sculpturing is formed by the application to the surface 2 of material identical with or different from that of the stent 1. These arrangements are generally preferred when greater or smaller undercut zones are desired on the surface 2.

[0033] In any case, objects substantially similar to those described at the beginning of this detailed description can be achieved by treating the surface 2 in ways intended to confer a generally sculpted appearance thereon.

[0034] In relation to this, Figure 4 illustrates the results obtained by subjecting the outer surface 2 to sand-blasting or shot-blasting (a term reserved for a treatment which - instead of using sand as in sand-blasting - is effected using microspheres ("balls") as the ballistic agents, for impact with the treated surface).

[0035] Figure 5, which represents the invention illustrates the results of mechanical scoring operation (incision or knurling) performed on the outer surface 2 of the stent.

[0036] Finally, Figure 6 illustrates the results obtained from a localised chemical attack (etching) of the surface 2. This method is effected using a resist material (for example, photoresist) which, following exposure through masks or polymerisation using laser beams, is selectively removed from some zones of the surface 2 so as to enable the attack thereof. The resist tracks remaining on the surface 2 are then removed by washing.

[0037] This technology is well known in the art (for example, for the manufacture of integrated circuits) and does not need to be illustrated in great detail in this context.

[0038] Results substantially similar to those illustrated at 7 in Figure 5 and, in particular, at 8 in Figure 6, can also be obtained by incision using laser beams, for example, before or after the operation for cutting the stent structure from a blank constituted by a microtube of metal.

[0039] As a rule, all of the solutions illustrated in Figures 1 to 6, and any equivalents thereto, can apply to stents obtained from a metal microtube, possibly manufactured totally or partly by sintering, as well as stents obtained from a wire, the processes illustrated being performed either before or after cutting the tube and/or winding the wire. For reasons of manufacturing simplicity, the applicant has in any case established that it is preferred to form the surface sculpturing before cutting the tube or winding the wire.

Claims

1. A stent for angioplasty including a body (1) of generally tubular shape having an inner surface and an outer surface (2), the said stent being capable of being dilated in use from a radially-contracted position to a radially-expanded position, having on at least part of the said outer surface (2) surface sculpturing constituted by formations on the surface (2) of the stent (1) itself with an effective quantity of agent or active principle applied selectively thereon at said formations, wherein said formations are in the form of incisions, and said incisions are in the form of channels or grooves, **characterized in that** said formations have a closed perimeter on all sides and an open top and have a symmetric trapezoidal perimeter wherein the bottom of the formation is narrower than the open top.

2. A stent according to Claim 1, **characterised in that** the said sculpturing is only present on the outer surface (2) of the stent, the inner surface of the stent (1) being substantially smooth.

3. A stent according to Claim 1 or Claim 2, **characterised in that** it has a coating of biocompatible carbon material, at least on the said inner surface.

4. A stent according to any of Claims 1 to 3, **characterised by** being constituted, in at least one part corresponding to said surface sculpturing by a sintered body.

5. A stent according to any of the preceding claims, **characterised in that** said agent or active principle include an agent or active principle for directly resisting restenosis of the treated site.

6. A stent according to any of the preceding claims, **characterised in that** said agent or active principle includes an antithrombogenic agent.

7. A stent according to any of the preceding claims, **characterised in that** said stent has an apertured structure.

8. A stent according to Claim 7, **characterised in that** said stent has a mesh-like structure.

9. A stent according to any of the preceding claims, **characterised in that** said formations are obtained by means of a mechanical operation such as incision or knurling.

10. A stent according to any of claims 1 to 8, **characterised in that** said formations are obtained by means of localised chemical attack of the surface (2) of the stent.

11. A stent according to any of claims 1 to 8, **characterised in that** said formations are obtained by incision using laser beam.

12. A method for producing stents for angioplasty comprising a body (1) of a generally tubular shape having an inner surface and an outer surface (2), the said stent being capable of being dilated in use from a radially-contracted position to a radially-expanded position, said method including an operation for forming on at least part of the said outer surface (2) surface sculpturing by creating formations on the surface (2) of the stent (1) itself and the operation of selectively applying thereon an effective quantity of agent or active principle at said formations, wherein said formations are in the form of incisions, and said incisions are in the form of channels or grooves, **characterised in that** said formations have a closed perimeter on all sides and an open top and have a symmetric trapezoidal perimeter wherein the bottom of the formation is narrower than the open top.

13. A method according to Claim 12, **characterised in that** said sculpturing is only formed on the outer surface (2) of the stent, the inner surface of the stent (1) being kept substantially smooth.

14. A method according to Claim 12 or Claim 13, **characterised in that** it includes the operation of forming a coating of biocompatible carbon material on at least the said inner surface.

15. A method according to any of Claims 12 to 14, **characterised in that** at least one part of the stent corresponding to said surface sculpturing is realized by sintering.

16. A method according to any of Claims 12 to 15, **characterised in that** said agent or active principle includes an agent or active principle for directly resisting restenosis of the treated site.

17. A method according to any of Claims 12 to 16, **characterised in that** said agent or active principle includes an antithrombogenic agent.

18. A method according to any of Claims 12 to 17, **characterised in that** said stent has an apertured structure.

19. A method according to Claim 18, **characterised in that** said stent has a mesh-like structure.

20. A method according to any of Claims 12 to 19, **characterised in that** said formations are formed using a method chosen from the group comprising: scoring, incision, knurling, chemical attack, photoincision.

21. A method according to Claim 20, **characterised in that** said formations are obtained by means of a mechanical operation such as incision or knurling.

22. A method according to any of Claims 12 to 19, **characterised in that** said formations are obtained by means of localised chemical attack of the surface (2) of the stent.

23. A method according to any of Claims 12 to 19, **characterised in that** said formations are obtained by incision using laser beam.

Patentansprüche

1. Stent für Angioplastie mit einem Körper (1) von im Allgemeinen rohrförmiger Form mit einer inneren Oberfläche und einer äußeren Oberfläche (2), wobei der Stent bei Benutzung von einer radial zusammengezogenen Position zu einer radial ausgedehnten Position aufweitbar ist und auf mindestens einem Teil der äußeren Oberfläche (2) eine Oberflächenprofilierung aufweist, welche durch Gebilde auf der Oberfläche (2) der Stents (1) selbst mit einer effektiven Menge eines Agens oder aktiven Elementes gebildet ist, welches bei den Gebilden selektiv aufgebracht, wobei die Gebilde die Form von Einschnitten aufweisen und die Einschnitte die Form von Kanälen oder Nuten aufweisen, **dadurch gekennzeichnet, dass** die Gebilde eine geschlos-

sene Begrenzung auf allen Seiten und eine offene Oberseite und eine symmetrische trapezförmige Begrenzung aufweisen, wobei der Boden des Gebildes schmaler als die offene Oberseite ist.

2. Stent nach Anspruch 1, **dadurch gekennzeichnet, dass** die Profilierung nur auf der äußeren Oberfläche (2) der Stents vorhanden sind, wobei die innere Oberfläche der Stents (1) im Wesentlichen glatt ist.

3. Stent nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** er einen Überzug aus biokompatiblem Kohlenstoffmaterial mindestens auf der inneren Oberfläche aufweist.

4. Stent nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** er in mindestens einem Teil entsprechend der Oberflächenprofilierung durch einen gesinterten Körper gebildet ist.

5. Stent nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Agens oder aktive Element ein Agens oder aktives Element zum direkten Widerstehen von Restenosis des behandelten Ortes aufweist.

6. Stent nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Agens oder aktive Element ein antithromboseerzeugendes Agens aufweist.

7. Stent nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Stent eine geöffnete Struktur aufweist.

8. Stent nach Anspruch 7, **dadurch gekennzeichnet, dass** der Stent eine netzartige Struktur aufweist.

9. Stent nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Gebilde mit Hilfe eines mechanischen Bearbeitungsvorgangs, wie Einschneiden oder Rändeln, entstanden sind.

10. Stent nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** die Gebilde mit Hilfe eines lokalisierten chemischen Angriffs der Oberfläche (2) der Stents entstanden sind.

11. Stent nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** die Gebilde durch Einschneiden unter Verwendung eines Laserstrahls entstanden sind.

12. Verfahren zum Herstellen von Stents für Angioplastie mit einem Körper (1) von im Allgemeinen rohrförmiger Form mit einer inneren Oberfläche und einer äußeren Oberfläche (2), wobei der Stent bei Benutzung von einer radial zusammengezogenen Position zu einer radial ausgedehnten Position aufweitbar ist, wobei das Verfahren einen Bearbeitungsvorgang zum Ausbilden einer Oberflächenprofilierung auf mindestens einem Teil der äußeren Oberfläche (2) durch Ausbilden von Gebilden auf der Oberfläche (2) der Stents (1) selbst und den Bearbeitungsvorgang eines selektiven Aufbringens einer effektiven Menge eines Agens oder aktiven Elements bei den Gebilden aufweist, wobei die Gebilde die Form von Einschnitten aufweisen und die Einschnitte die Form von Kanälen oder Nuten aufweisen, **dadurch gekennzeichnet, dass** die Gebilde eine geschlossene Begrenzung auf allen Seiten und eine offene Oberseite und eine symmetrische trapezförmige Begrenzung aufweisen, wobei der Boden des Gebildes schmaler als die offene Oberseite ist.

13. Verfahren nach Anspruch 12, **dadurch gekennzeichnet, dass** die Profilierung nur auf der äußeren Oberfläche (2) der Stents geformt ist, wobei die innere Oberfläche der Stents (1) im Wesentlichen glatt bleibt.

14. Verfahren nach Anspruch 12 oder 13, **dadurch gekennzeichnet, dass** es den Bearbeitungsvorgang des Ausbildens eines Überzugs aus biokompatiblem Kohlenstoffmaterial auf mindestens der inneren Oberfläche aufweist.

15. Verfahren nach einem der Ansprüche 12 bis 14, **dadurch gekennzeichnet, dass** mindestens ein Teil der Stents entsprechend der Oberflächenprofilierung durch Sintern verwirklicht wird.

16. Verfahren nach einem der Ansprüche 12 bis 15, **dadurch gekennzeichnet, dass** das Agens oder aktive Element ein Agens oder aktives Element zum direkten Widerstehen von Restenosis des behandelten Ortes aufweist.

17. Verfahren nach einem der Ansprüche 12 bis 16, **dadurch gekennzeichnet, dass** das Agens oder aktive Element ein antithromboseerzeugendes Agens aufweist.

18. Verfahren nach einem der Ansprüche 12 bis 17, **dadurch gekennzeichnet, dass** der Stent eine geöffnete Struktur aufweist.

19. Verfahren nach Anspruch 18, **dadurch gekennzeichnet, dass** der Stent eine netzartige Struktur aufweist.

20. Verfahren nach einem der Ansprüche 12 bis 19, **dadurch gekennzeichnet, dass** die Gebilde unter Verwendung eines Verfahrens geformt werden, ausgewählt aus der Gruppe von Einkerben, Ein-

schneiden, Rändeln, chemischer Angriff, Fotoeinschneiden.

21. Verfahren nach Anspruch 20, **dadurch gekennzeichnet, dass** die Gebilde mit Hilfe eines mechanischen Bearbeitungsvorgangs, wie Einschneiden oder Rändeln, erhalten werden.

22. Verfahren nach einem der Ansprüche 12 bis 19, **dadurch gekennzeichnet, dass** die Gebilde mit Hilfe eines lokalisierten chemischen Angriffs der Oberfläche (2) der Stents erhalten werden.

23. Verfahren nach einem der Ansprüche 12 bis 19, **dadurch gekennzeichnet, dass** die Gebilde durch Einschneiden unter Verwendung eines Laserstrahls erhalten werden.

Revendications

1. Stent pour angioplastie comprenant un corps (1) de forme générale tubulaire possédant une surface intérieure et une surface extérieure (2), ledit stent pouvant être dilaté en cours d'utilisation depuis une position contractée radialement pour venir dans une position déployée radialement, comportant sur au moins une partie de ladite surface extérieure (2) une sculpture superficielle constituée par des configurations présentes sur la surface (2) du stent (1) lui-même avec une quantité effective d'un agent ou d'un principe actif appliqué sélectivement sur cette surface au niveau desdites configurations, lesdites configurations étant présentes sous la forme d'incisions et lesdites incisions se présentant sous la forme de canaux ou de rainures, **caractérisé en ce que** lesdites configurations possèdent un pourtour fermé sur tous les côtés et une partie supérieure ouverte et possèdent un pourtour trapézoïdal symétrique, la partie inférieure de la configuration étant plus étroite que la partie supérieure ouverte.

2. Stent selon la revendication 1, **caractérisé en ce que** ladite sculpture est présente uniquement sur la surface extérieure (2) du stent, la surface intérieure du stent (1) étant sensiblement lisse.

3. Stent selon la revendication 1 ou la revendication 2, **caractérisé en ce qu'**il possède un revêtement formé d'un matériau à base de carbone biocompatible, au moins sur ladite surface intérieure.

4. Stent selon l'une quelconque des revendications 1 à 3, **caractérisé en ce qu'**il est constitué, dans au moins une partie correspondant à ladite sculpture superficielle, par un corps fritté.

5. Stent selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit agent ou principe actif inclut un agent ou principe actif pour résister directement à une resténose du site traité.

6. Stent selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit agent ou principe actif inclut un agent anti-thrombogène.

7. Stent selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit stent possède une structure ajourée.

8. Stent selon la revendication 7, **caractérisé en ce que** ledit stent possède une structure de forme maillée.

9. Stent selon l'une quelconque des revendications précédentes, **caractérisé en ce que** lesdites configurations sont obtenues au moyen d'une opération mécanique telle qu'une incision ou un moletage.

10. Stent selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** lesdites configurations sont obtenues au moyen d'une attaque chimique localisée de la surface (2) du stent.

11. Stent selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** lesdites configurations sont obtenues au moyen d'une incision utilisant un faisceau laser.

12. Procédé pour fabriquer des stents pour angioplastie comprenant un corps (1) de forme générale tubulaire possédant une surface intérieure et une surface extérieure (2), ledit stent pouvant être dilaté en cours d'utilisation depuis une position contractée radialement pour venir dans une position déployée radialement, comportant sur au moins une partie de ladite surface extérieure (2) une sculpture superficielle constituée par des configurations présentes sur la surface (2) du stent (1) lui-même avec une quantité effective d'un agent ou d'un principe actif appliqué sélectivement sur cette surface au niveau desdites configurations, lesdites configurations étant présentes sous la forme d'incisions et lesdites incisions se présentant sous la forme de canaux ou de rainures, **caractérisé en ce que** lesdites configurations possèdent un périmètre à porteur fermé sur tous les côtés et une partie supérieure ouverte et possèdent un pourtour trapézoïdal symétrique, la partie inférieure de la configuration étant plus étroite que la partie supérieure ouverte.

13. Procédé selon la revendication 12, **caractérisé en ce que** ladite sculpture est forme uniquement sur la surface extérieure (2) du stent, la surface intérieure du stent (1) étant sensiblement lisse.

14. Procédé selon la revendication 12 ou la revendication 13, **caractérisé en ce qu'**il inclut l'opération consistant à former un revêtement formé d'un matériau à base de carbone biocompatible sur au moins ladite surface intérieure.

15. Procédé selon l'une quelconque des revendications 12 à 14, **caractérisé en ce qu'**au moins une partie du stent correspondant à ladite sculpture superficielle est réalisée par frittage.

16. Procédé selon l'une quelconque des revendications 12 à 15, **caractérisé en ce que** ledit agent ou principe actif inclut un agent ou principe actif pour s'opposer directement à une resténose du site traité.

17. Procédé selon l'une quelconque des revendications 12 à 15, **caractérisé en ce que** ledit agent ou principe actif inclut un agent anti-thrombogène.

18. Procédé selon l'une des revendications 12 à 17, **caractérisé en ce que** ledit stent possède une structure ajourée.

19. Procédé selon la revendication 18, **caractérisé en ce que** ledit stent possède une structure maillée.

20. Procédé selon l'une quelconque des revendications 12 à 19, **caractérisé en ce que** lesdites configurations sont formées en utilisant un procédé choisi dans le groupe comprenant:

    l'entaillage, l'incision, le moletage, l'attaque chimique, la photo-incision.

21. Procédé selon la revendication 20, **caractérisé en ce que** lesdites configurations sont obtenues au moyen d'une obturation mécanique telle qu'une incision ou un moletage.

22. Procédé selon l'une quelconque des revendications 12 à 19, **caractérisé en ce que** lesdites configurations sont obtenues au moyen d'une attaque chimique localis4ée de la surface (2) du stent.

23. Procédé selon l'une quelconque des revendications 12 à 19, **caractérisé en ce que** lesdites formations sont obtenues au moyen d'une incision en utilisant un faisceau laser.

FIG. 1

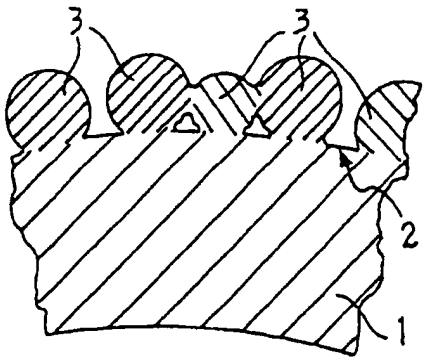

FIG. 2

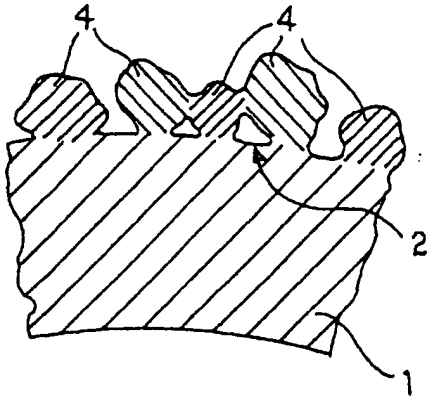

FIG. 3

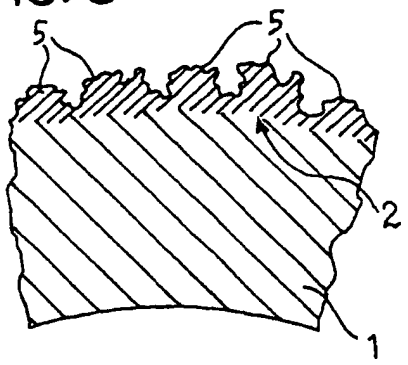

FIG. 4

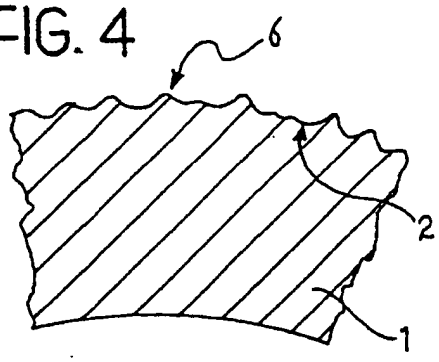

FIG. 5

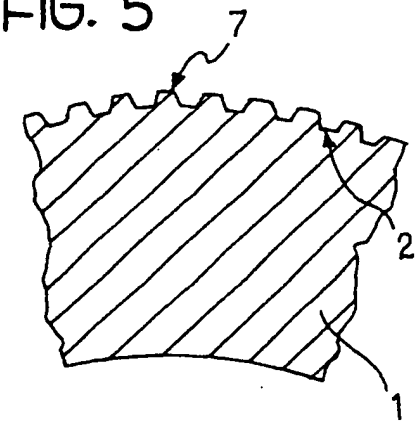

FIG. 6